Rhodora

JOURNAL OF

THE NEW ENGLAND BOTANICAL CLUB

Vol. 53 **June, 1951** **No. 630**

CALLITRICHE IN THE NEW WORLD

NORMAN C. FASSETT

THIS treatment of the species of *Callitriche* occurring in the Western Hemisphere, from Alaska and Greenland to Cape Horn, was started in the summer of 1945 while the writer was working at the Smithsonian Institution under a grant from the Wisconsin Alumni Research Foundation. Continued study has been made possible by the generous loans of material from many herbaria, including: Gray Herbarium (GH); Missouri Botanical Garden (MO); New York Botanical Garden (NY); United States National Herbarium (US); University of California (UC); Universidad Nacional de La Plata (LP); Instituto de Botanica, São Paulo (SP); Chicago Museum of Natural History (CM); New England Botanical Club (NEBC); Oberlin College (OB); University of West Virginia (WVA); University of Tennessee (TENN); University of Georgia (GA); herbarium of Mr. R. F. Thorne; University of Wisconsin (WIS).

For assistance in the interpretation of the morphology of various structures, I am indebted to my colleagues, Professors Emma L. Fisk and Richard I. Evans, and to Professor Arthur J. Eames.

Ranges are plotted on outline maps copyrighted by McKnight

PLATE 1167

Fruits are shown 64 times natural size. Photographs by Langdon Divers.
Fig. 1. *C. verna.* Quebec, *Fassett 27795* (WIS). Fig. 2. *C. verna.* Colorado, *Mackenzie 359* (MO). Fig. 3. *C. longipedunculata.* California, *Hoover 776* (UC). Fig. 4. *C. heterophylla.* Tennessee, *Svenson 10151* (WIS). Fig. 5. *C. heterophylla.* New Jersey, *Adams 298* (GH). Fig. 6. *C. longipedunculata.* California, *Mason 5193* (UC). Fig. 7. *C. heterophylla.* Massachusetts, *Harper* (WIS). Fig. 8. *C. heterophylla* var. *Bolanderi.* Washington, *Muenscher 9949* (WIS). Fig. 9. *C. heterophylla.* Illinois, *Schneiders* in 1893 (WIS).

and McKnight Publishing Company, and used by permission of the publishers.

The taxonomy of *Callitriche* is difficult. Most species are polymorphic (see Plate 1168, with 10 individuals of one species), and individuals of very similar form may be found in different species. Fruit is therefore necessary for identification in all cases. While fruits are present on a majority of collections, they are often evident only after considerable search with a low power binocular microscope. Most fruits are a millimeter or less in diameter so that close inspection is necessary to see the minute characters used to differentiate species. Magnification of at least 20 times is necessary, and 30 times is often better. Size and proportions of fruit, presence or absence of wings, nature of the commissural groove as shown in a cross-section, and sometimes the surface markings of the mericarps account for most of the key characters.

The nomenclature of *Callitriche* is difficult. Nearly every early name was based entirely on foliage characters that are paralleled in many species. Most of these names are, therefore, *nomina ambigua*, and their list includes some of the best-known in the genus: *C. verna*, *C. palustris*, *C. heterophylla*, *C. autumnalis*, *C. hermaphroditica*, *C. stagnalis*, *C. turfosa*, and *C. terrestris*. It has therefore been necessary to fix the applications of these names (in absence of type specimens) by the usage of the first writer to describe the fruit. Happily, this does not result in any major upsets in nomenclature. *C. terrestris* Raf., interpreted by Torrey in 1826, replaces *C. Austini* of American literature, described in 1867 (and based incidentally on a mixture of 3 species). *C. palustris*, used by most recent American authors, gives way to *C. verna*, the traditional name in European literature; both names were used in an idefinite sense by Linnaeus, and *C. verna* was first precisely interpreted in 1831, *C. palustris* not until 1897 in Britton & Brown's Illustrated Flora.

Structure of the Fruit of Callitriche

Several fruits are illustrated, natural size, in Fig. 3, 5, 7, 8 and 9 on Plate 1169, where they appear as round dots about a millimeter in diameter in the leaf-axils. Enlarged photographs are shown in Plate 1167.

The fruit of *Callitriche* consists of 2 carpels, each of which is divided into 2 one-seeded mericarps (Fig. 1b). The orientation of the two stigmas, as shown in Fig. 4a and 5a, suggests that the true partition between carpels is the one lying horizontally in Fig. 4c, so that in a face view of the fruit, like Fig. 3b, only one carpel is visible. The false partition then appears as a facial groove, visible as a straight line up and down the middle of the fruit, in Fig. 2b, 3b, 4b, 5b. The commissural groove, or groove between carpels, appears only when the fruit is viewed from one edge, as in Fig. 11b, 12b, etc., or is seen in cross-section when the two commissural grooves appear at the two ends as in Fig. 1b, 2c, 3c, and 4c.

The surface of the mericarps appears reticulate on the dried fruits. Plate 1167 shows photographs of dried fruits. Fig. 3d, 4d, 13d, 13i, 13v, etc., are camera lucida drawings of pericarps stripped from fruits that have been cleared by boiling in KOH. The actual nature of the reticulate surface is shown in Fig. 13q, a portion of a section made by my colleague, Professor Richard I. Evans, from fresh material. The drawing shows, starting at the outside (the top in the drawing): the pericarp, consisting of 2 or 3 layers of very thin-walled cells and a layer of cells with all but the outer wall thickened; the seed-coat, a single layer of very thin cells; the endosperm, of large oval loosely packed cells; and the embryo, of smaller, conspicuously nucleated cells. The reticulate appearance is due to the collapse of the outer thin-walled cells of the pericarp, so that under the microscope one looks into the cavities of the thick-walled cells.

A fresh fruit just out of the water, viewed with a binocular microscope of 20–30 power, has a remarkable appearance. The lines between the thick-walled cells show as threads of shining silver. There must be a capillary but continuous and branched intercellular space, filled with air, between these cells.

The wings may be of two types. The true wing is a membranous outgrowth from the margin of the carpel (Fig. 4b, 4c) and is of a different texture and has different markings from the reticulate body of the carpel. The wing may have heavy radial markings as in Fig. 3d, 4d, or almost no markings as in Fig. 10v, 23b. There is sometimes present what may be called a false wing. This is best developed in *C. hermaphroditica*, a species usually described as having a broad-winged fruit. Fig. 24d shows such a fruit; the true wing is very narrow, and the false wing (shaded with a few radial lines) is broad. The false wing is formed, apparently, by the uninflated outer part of the carpel, marked III in Fig. 24c. The nature of the false wing is also shown in Fig. 24b, where it is very conspicuous and no true wing is shown. This contrasts with Fig. 23e which shows the knife-like appearance of the true wing in cross-section. Fig. 24f is a camera lucida drawing of the edge of the carpel of *C. hermaphroditica*, and it shows the very narrow true wing to the right, and the surface of the false wing marked like the ordinary carpel wall.

Some development of a false wing due to incomplete filling of the mericarps by the seeds is shown in Fig. 4 & 5 on Plate 1167.

Morphology and Cytology

Professor A. J. Eames sends me the following notes on the morphology of the fruit of *Callitriche:*

"There are, as usually described, two carpels each with two marginal ovules. The carpels are flattened dorso-ventrally so that the midrib (with dorsal bundle) lies close to the placental margins. The dorsal (midrib) bundle rarely shows and then only as one xylem element. The ventral or marginal bundles, though weak, are definite. There are the normal two for each carpel. Thus the axile placentation shows a flattened ring of four bundles, a normal condition for axile placentation with two carpels.

"Even in flower the midrib region of each carpel extends ventrally almost to the placenta. Later it apparently extends farther, reaching, with this false partition, the placenta, dividing the locule and separating the two ovules.

"In the mature fruit, dehiscence is through this false partition and the placental region of each carpel. Also the two carpels separate. This morphological condition is closely like that in the mints, and borages.

"The styles stand in normal position over the midribs of the carpels; the stigma is therefore not commissural."

The haploid chromosome number in the Sect. Pseudocallitriche is 3; in Sect. Callitriche it is 5 in some species, 10 in others, and rarely 19 or 20. This is according to Jorgensen,[1] who also

[1] Bot. Tidskrift 38: 81–122. 1923.

describes the development of the gametophytes and discusses the systematic position of the genus.

Some Techniques in Handling Small Seeds and Fruits

Small fruits like those of *Callitriche* are difficult to work with. First, a fruit must be located on the sheet. This is best done with a low power binocular microscope, after which an arrow may be marked on the sheet for future guidance, or, better still, a pencil line may be drawn leading among the stems and leaves to the fruit. It is still difficult to compare fruits from two sheets. For this purpose, the most successful technique involves use of a slide of cellulose acetate, perhaps 1 x 1½ inches. The fruit is removed from the plant and placed on the slide; a single drop of acetone will make it adhere to the acetate. Now, the slide can be superimposed on any specimen; it is transparent and a fruit lying below it can easily be compared with the one fastened to it.

Cross-sections of fruits are often necessary (Fig. 1b). A fruit is laid on the acetate slide, and wetted with a drop of acetone. Before the acetone has dried, a drop of a thin solution of cellulose acetate is put on, to imbed the fruit. When this has hardened, two parallel cuts through the middle of the fruit (performed with a razor blade under the binocular) makes a section that can be freed by another cut under the whole fruit. The section is laid flat, and secured by a drop of acetone. If the fruit is sectioned without imbedding the mericarps usually separate.

To determine the nature of the commissural groove an edge view of the fruit is often useful (Figs. 10c, 10f, etc.). The fruit is laid on the cellulose acetate slide and, under a binocular microscope cut lengthwise along the facial groove. Each half-fruit is put in an upright position (the cut surface against the slide) and secured in place with a drop of acetone. Since these pieces are easily knocked off, they may be protected by small pieces of cellulose acetate placed on each side of the preparation and fastened down with a drop of acetone.

For microscopic examination of wings and surface of carpels (Figs. 1c, 3d, 4d) the fruits are boiled in KOH, then washed in water. Each mericarp (the fruit will usually have fragmented by this time) is dissected while still wet, either by squeezing out the seed (under the binocular) or by stripping off the pericarp.

The pericarps are moved to a drop of alcohol on the slide, for dehydration. They are removed from the alcohol and covered with a drop of acetone, another small piece of cellulose acetate is put on for a cover, and the preparation pressed together for a few seconds. The mount is then permanent.

For many collections of *Callitriche*, slides have been prepared in this fashion, showing a fruit in face view, in edge view, and in section, with a piece of pericarp and wing for microscopic examination. These slides appear to be permanent and are being placed in envelopes on the herbarium sheets. I can only hope that they may keep as well as have the meticulously prepared dissections by Dr. Engelmann, which it has been my privilege to examine in the collections of the Missouri Botanical Garden.

These techniques have been described in some detail because they proved to save so much time once they were developed. They may be easily adapted for use in other groups. Seeds and other small objects may be readily mounted on acetate slides, usually with a single drop of acetone that dries in a few seconds. Flowers and other objects that have been boiled for softening and dissection must be dehydrated before being stuck down with acetone; this is readily accomplished by running a small stream of alcohol over the preparation. The slides are easily marked with India ink and may be labelled with collector's name and number, etc., for identification.

For quick repairs to herbarium sheets, cellulose acetate is invaluable. This is particularly true in the case of *Callitriche*, and for other aquatics that have only been floated out on the sheet without adhesive. A very thin solution of cellulose acetate in acetone is used; painted thinly across a specimen or dotted on locally, it secures the plant to the paper, dries in a few minutes, and is visible only with the most careful scrutiny.

The Sections of Callitriche

Sect. 1. Microcallitriche sect. nov., plantae palustres vel subterrestres; foliis subuniformibus; foliorum pilis peltatis nullis aut raris; floribus sin bracteis; antheribus 0.1–0.2 mm. latis; staminibus 0.2–1.2 mm. longis; stigmatibus 0.2–1.2 mm. longis; fructibus plerumque latioris quam longis.—Species Typica, *C. deflexa* R. Br.

Section *Microcallitriche* is best developed from southern and extreme western United States southward to Argentina; a few species are found in Japan, Australia and New Zealand. These are the most nearly terrestrial species of *Callitriche*, and several kinds grow where the soil is only somewhat muddy in the spring and becomes desiccated as the season progresses.

Sect. 2. CALLITRICHE. *Eucallitriche* Hegelm. Monogr. Gattung *Callitriche* 54, 1864, emended. Plants aquatic or in mud at the water's edge; most species highly polymorphic, amphibious and adaptable to various depths of water or muddy shores; submerged leaves typically linear, 1-nerved, bidentate at tip, but sometimes obovate and petioled; floating leaves typically obovate, 3–5-nerved, and narrowed to a flat petiole; leaves with peltate scales (Figs. 17c, 17d) that are 4-, 8-, or 16-parted; flowers subtended by two white inflated bracts; anthers 0.2–1.5 mm. wide; stamens elongating to 1.5–3 mm.; styles 0.7–6 mm. long; length of fruit usually equalling or exceeding the width.—As TYPE SPECIES may be named *C. verna* L. emend. Kütz. (*C. palustris* of many American authors).

Section *Callitriche* stands in many respects intermediate between the other two sections. Its members may sometimes be found intermixed with those of one of the other sections. When well submersed its representatives may have only linear leaves and simulate Sect. 3, but when stranded on a muddy shore the same species may be turf-like with only broad leaves to simulate Sect. 1. A single clone may grow partly on the shore and partly in the water and exhibit both life forms at the same time. A very common phase has the lower leaves linear, while the upper ones are broad and crowded in a rosette floating on the surface; these floating rosettes give the common name "Water Starwort." Such plants often show these rosettes much better in their own habitat than on herbarium sheets. Members of this group are found on all continents.

Sect. 3. PSEUDOCALLITRICHE Hegelm. Mongr. Gattung Callitriche 61. 1864. Plants always submersed; leaves uniform, dark metallic green, often with a slightly darker margin, without peltate scales, nearly linear but actually widest at base, rounded to the bases which are sometimes slightly fused but are not connected by a membranous wing, gradually tapered to the bidentate apex; flowers without bracts; surface of fruit obscurely and irregularly pitted; fruit with a broad false wing and a narrow true wing.—As TYPE SPECIES may be named *C. hermaphroditica* L. (*C. autumnalis* Hegelm., l. c.).

Section *Pseudocallitriche* represents the most aquatic extreme of the genus. Its members occur in cool water throughout Europe and in northern North America.

KEY TO SPECIES OF CALLITRICHE IN THE WESTERN HEMISPHERE

a. Leaves bright green, of various shapes, the linear 1-nerved ones tapering to a clasping base (Fig. 10w); nodes with a narrow membranous wing connecting the leaf-bases (Fig. 1a, 2a, 3a, 4a, 5a, 7a, 9a, 10g, 10p, 10w, 15b, 16e); surface of fruit usually sharply reticulate.

b. Fruit broader than high (Figs. 1–7) except in *C. occidentalis* (Fig. 8); stigmas 0.3–1 mm. long (Fig. 1a, 3b, 7a); stamens 0.2–1.2 mm. long and not elongating as the fruit develops; anthers 0.1–0.2 mm. wide; flowers without bracts; leaves and stems mostly without peltate scales; leaves essentially uniform, narrowly oblong (Fig. 5a), or spatulate (Fig. 4a), or broadly oblanceolate (Fig. 1a), 1-3-nerved (often obscurely so); plants mostly terrestrial or on wet mud. Sect. 1. MICROCALLITRICHE.

c. Fruit 0.5–1.2 mm. wide, not gibbous at base.

d. Width of fruit exceeding the height by 0.1 mm. (Fig. 1a); face of mericarps convex (Fig. 1b) . . . . 1. *C. turfosa.*

d. Width of fruit exceeding the height by 0.2 mm.; face of mericarps nearly flat (Fig. 2c).

e. Wing, or margin of carpels, spreading.

f. Fruit 0.9 mm. or less wide, pedicelled or sessile; wing 0.08 mm. or less wide.

g. Margin of carpels with a definite scarious wing 0.03–0.08 mm. wide, under high magnification appearing with radial extensions from the brown reticulations on the face of the carpel, these extensions branching and anastomosing (Fig. 2d); stigmas loosely ascending (Fig. 2b), often caducous; leaves 3-veined, the midrib and often the lateral veins evident (Fig. 2a) . . . . 2. *C. deflexa.*

g. Margin of carpels appearing as if not winged but under high magnification showing a wing 0.01–0.03 mm. wide, the radial extensions of the brown reticulations from the face of the carpel simple or forking, not anastomosing (Fig. 3d); styles usually deflexed (Fig. 3b); leaves 3-veined but the veins very obscure (Fig. 3a) . . . . 3. *C. terrestris.*

f. Fruit 0.8–1.2 mm. wide, pedicelled (Fig. 4a); wing usually 0.1 mm. or more wide (Fig. 4b).

h. Leaves spatulate, the upper 0.8–2 mm. wide, 3-nerved (Fig. 4a); wing of fruit 0.1–0.2 mm. wide . . . . 4. *C. marginata.*

h. Leaves linear, 0.6 mm. or less wide, 1-nerved or with nearly obsolete lateral veins (Fig. 5a); wing of fruit nearly obsolete . . . . 5. *C. sepulta.*

e. Wing and thin margin of carpel turned outward at right angles to the surface of the fruit or revolute and appearing like a thickened margin (Fig. 6a, 6b) . . . . 6. *C. Nuttallii.*

c. Fruit 0.3–0.8 mm. wide, more or less gibbous at base (Fig. 7a).

i. Fruit 0.5–0.8 mm. wide, not quite so high (Fig. 7a, 7b, 7c) . . . . 7. *C. peploides.*

i. Fruit 0.3–0.4 mm. wide, about as high (Fig. 8) . . . 8. *C. occidentalis.*

b. Fruit as high as wide or a little higher, rarely slightly wider than high; stigmas 0.7–6 mm. long (Fig. 10g, 12g, 15b, 16h); stamens elongating as the fruit matures, to 1.5–3 mm.; anthers 0.3–1.5 mm. wide; flowers with 2 whitish inflated bracts at base (Fig. 10g, Fig. 2 on Plate 1167); leaves and upper nodes usually with peltate scales (Fig. 9a, 13Ad, 17c, 17d, 23j, 23k); plants amphibious, growing entirely submersed or with a terminal rosette of floating leaves, or as a mat stranded on the mud; leaves of various types on different plants or on the same plant (Figures on Plate 1168). Sect. 2. CALLITRICHE.

j. Leaves succulent, connate at base to make a cup about 0.5 mm. deep (Fig. 9a); stems firm and opaque, appearing homogeneous when pressed . . . . 9. *C. antarctica.*

j. Leaves thin and membranous, connected at base by a very narrow wing; stems weak, pressing flat and membranous except for the firmer stele.

k. Fruit rarely more than 1.2 mm. wide (–1.5 mm. in a South American species); wing of fruit, if present, sharply demarked from the reticulate face of the mericarp; reticulations, when seen under high power, dark brown or orange, and, under low power (10–30 × magnification) appearing clear and distinct.

l. Wings of fruit, if present, only on the outside of the mericarps and extending slightly or not at all around the base or summit to the facial groove (Fig. 10a, 18a, 19c, 20c, 21b).

m. Carpels more broadly rounded toward the summit than toward the base, so that the fruit is slightly heart-shaped (Fig. 10a, 11a, 13e, 13Am, Fig. 1 & 5 on Plate 1167); wing, if present, broadest at the summit of carpels (Fig. 1 on Plate 1167).

n. Fruit 0.6–1.3 mm. wide.

o. Height of fruit exceeding the width by 0.2 mm. (many fig. on Plate 1172); surface of mericarps with reticulations tending to run in vertical rows (Fig. 1 & 2 on Plate 1167); lower end of mericarps curved outward so that the fruit is thickest at base (Fig. 10c, 10k, 10u) . . . . 10. *C. verna.*

o. Height of fruit equalling width (Fig. 12a, 12c, 13a, 13Ae), or height 0.1 mm. greater (Fig. 11a, 13d, 13Aa, 13Ap) or less (Fig. 13e, 13m) than width; reticulation of mericarps usually not at all in vertical rows (Fig. 4, 5, 7 on Plate 1167); lower end of mericarps straight so that fruit is thickest a little below the middle (Fig. 11b, 12b, 13f, 13Ab).

p. Commissural grooves wide (Fig. 11b, 11c); fruit 1.1–1.5 mm. high.

q. Fruit with well-differentiated white wings at summit (Fig. 11a); commissural grooves slightly U-shaped. . . 11. *C. albomarginata.*

q. Fruit wingless or with an obscure suggestion of wings; commissural grooves V-shaped . . . . 12. *C. heteropoda.*

p. Commissural grooves very narrow or edges of carpels in close contact (Fig. 13c, 13g, 13l, 13Ac, 13Af); fruit 0.6–1.2 mm. high .... 13. *C. heterophylla.*

n. Fruit 1.5 mm. wide .... 14. *C. quindiensis.*

m. Carpels equally rounded above and below (Fig. 15b, 16b, 17a, 18a, 21b), or some fruits narrowed toward base on a South American species with conspicuous wings (Fig. 18k); wing, when present, of equal width around the carpel (Fig. 18d, 19c, 21b).

r. Width of fruit equalling (Fig. 15b, 17a) or exceeding (Fig. 17e, 18a) the height, or fruit not more than 0.1 mm. higher than wide; fruit sessile except in a variety of *C. Lechleri.*

s. Stigmas sharply reflexed (Fig. 15b), usually persistent .... 15. *C. hamulata.*

s. Stigmas erect or ascending, often caducous.

t. Carpels wingless

u. Edges of carpels rounded, with almost no commissural groove (Fig. 16a) ...... 16. *C. anceps.*

u. Edges of carpels angled, with a wide V-shaped commissural groove (Fig. 17b) .... 17. *C. nubigena.*

t. Carpels winged.

v. Commissural groove deep and V-shaped (Fig. 18c, 18f); fruit slightly wider than high (Fig. 18d), often pedicelled .... 18. *C. Lechleri.*

v. Commissural groove shallow and U-shaped (Fig. 19a); fruit almost exactly as high as wide (Fig. 19c), always sessile .... 19. *C. trochlearis.*

r. Width of fruit less than the height by about 0.1 mm. (Fig. 20c, 21b); fruit pedicelled.

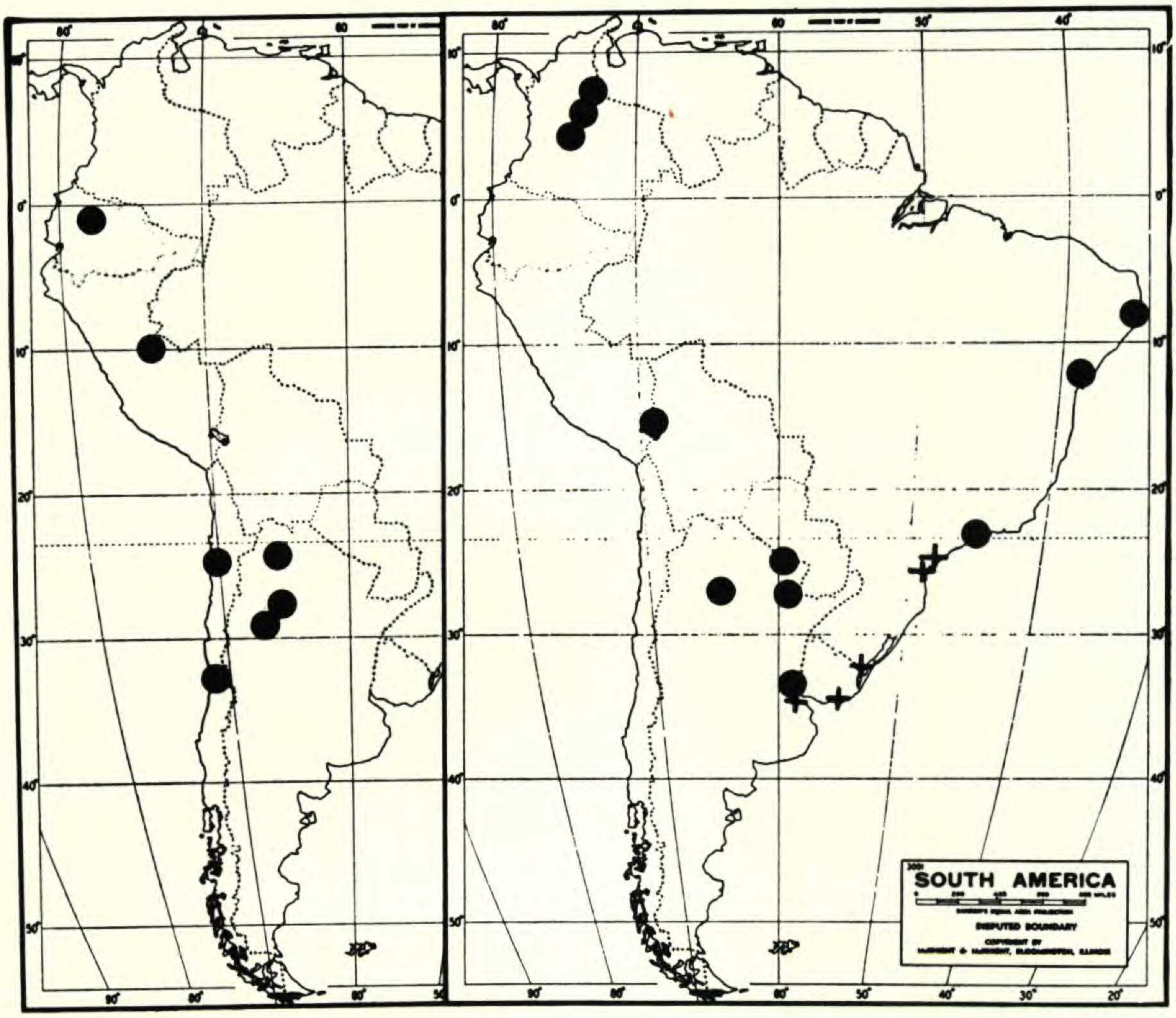
w. Fruit 0.8–0.9 mm. high, clearly reticulate on the faces, with an obscure wing on the outer margins of the mericarps (Fig. 20c). 20. *C. oblongicarpa.*

w. Fruit 1.0–1.4 mm. high, nearly black at maturity, obscurely reticulate on the faces, with a clearly defined wing around the outer margin of the carpels and extending slightly around the base of each mericarp (Fig. 21b) .... 21. *C. longipedunculata.*

l. Wing of fruit extending well around the base and apex of each mericarp so that the facial groove is very short (Fig. 22b) .... 22. *C. rimosa.*

k. Fruit 1.2–1.7 mm. wide; wing usually conspicuous but not usually clearly demarked from the reticulate faces of the mericarps; reticulations, when seen under high power, very pale, and, under low power, appearing rather obscure .... 23. *C. stagnalis.*

a. Leaves dark metallic green, all submersed, linear-lanceolate (Fig. 24j), narrowed to a clasping base, the bases not connected by a wing; faces of mericarps obscurely and irregularly pitted; plants strictly aquatic. Sect. 3. PSEUDO-CALLITRICHE .... 24. *C. hermaphroditica.*



1 (left). *C. turfosa.* 2 (right). *C. deflexa* var. *deflexa* (crosses), and var. *subsessilis* (dots) in South America.

1. **C. turfosa** Bert. emend. Hegelm. *C. turfosa* Bert. Amer. Journ. Sci. 19: 308. 1831, *nomen nudum;* Hegelm. Monographie Gattung Callitriche 59. 1864, in part; Hegelm. Verhandl. Bot. Ver. Brandenburg 9: 13. 1867.—Fruit 0.7–0.9 mm. wide, 0.6–0.8 mm. high, very narrowly winged all around (Fig. 1a), sessile or on peduncles up to 0.4 mm. long; mericarps plump, thinner toward the margins (Fig. 1b); stigmas 0.5–1.0 mm. long, loosely ascending, caducous or persistent; stamens 1 mm. or less long; anthers about 0.2 mm. wide; leaves essentially uniform, 2–4 mm. long, 0.75–1.5 mm. wide, 3-nerved.—On damp soil and in shallow water; Ecuador to northern Chile and eastern Argentina.—**Ecuador:** in Andibus Ecuadorensibus, 1857–9, *Spruce 5053* (GH, MO, NY). **Chile:** Dept. Junín, Carpapata above Huacapistana, 2700–3200 m., June 7, 1929, *Killip & Smith 24386* (US); Agua Dulce, lat. 25° 16′ S, Prov. Antofagasta, Dept. Taltal, Nov. 28, 1925, *Johnston 5187* (GH, US); Cechinalcito, Taltal, Nov. 11, 1936, *Montero 2974* (GH); Valparaiso, 1895, *Buchtien* (US). **Argentina:** Dept. Leales, Oct. 5, 1919, *Venturi 482* (US, GH); Dept. Capital, Rio Salé, Sept. 28, 1923, *Venturi 2066* (US); Prov. Jujuy, Dept. Capital, Rio Zapala, 1250 m., Oct. 3, 1938, *Eyerdam & Beetle 26315* (MO, GH, UC); Bosque de la Plata, prov. de Buenos Aires, Nov. 28, 1932, *Cabrera 2247* (LP).

According to Hegelmaier, 1867, *C. turfosa* as originally conceived (but not described) by Bertero, consisted of two entities, treated by Hegelmaier under the names *C. turfosa* and *C. marginata γ Lechleri*. Each of these is cited by Hegelmaier from Rancagua and Quillota, Chile, collected by Bertero. The only cited collection available to the present writer that can be definitely associated with *C. turfosa* is *Spruce 5053* from Ecuador which was not actually seen by Hegelmaier but included on the authority of Engelmann. The best clue afforded by the descriptions to the application of names to these two Andean species is in relative size of fruit: "Frucht gross" in *C. marginata*, including *γ Lechleri*, and "Frucht klein" in *C. turfosa*. The fruits of what is here recognized as *C. turfosa* are 0.7–0.9 mm. wide, while those of *C. Lechleri* are 1.0–1.4 mm. wide.

2. **C. deflexa** A. Br. ex Hegelm. Monogr. Callit. 58, t. 3. 1864; Hegelm. in Martius, Fl. Bras. 13, pt. 2. col. 13. 1882.

Fruit 0.5–0.9 mm. wide, 0.3–0.7 mm. high, sessile or on pedicels up to 4 mm. long; wings usually 0.03–0.08 mm. wide, nearly uniform around the fruit (Fig. 2b), with radial markings produced by the greatly anastomosing extensions of the markings from the faces of the carpels; stigmas 0.3–0.4 mm. long, irregularly erect or occasionally somewhat recurved, often caducous; anthers 0.1–0.2 mm. long, on filaments 0.2–0.5 mm. long (Fig. 2a); leaves 2–4 mm. long, 0.8–2.3 mm. wide, the midrib and often the two lateral veins evident.—Mexico to Argentina.

As first described in 1864, *C. deflexa* included plants with pedicelled fruits and those with sessile fruits, North American as well as South American. The specific name probably came from the deflexed stigmas of the North American component (here separated as another species), but the Brazilian plant with long

PLATE 1168

All figures are *C. heterophylla*, and are natural size, made by direct photographic prints from the pressed plants. All collections are in the Gray Herbarium.

Fig. 1. Virginia, *Fernald & Long 9969*. Fig. 2. New Jersey, *Bartram* in 1917. Fig. 3. New York, *House 20174*. Fig. 4. Rhode Island, *Reynolds 068*. Fig. 5. New York, *Raup 7697*. Fig. 6. Maryland, *Smith* in 1881. Fig. 7. New York, *Raup 7794*. Fig. 8. Virginia, *Fernald & Long 9970*. Fig. 9. Connecticut, *Andrews* in 1895. Fig. 10. Massachusetts, "Local Collection" in 1895.

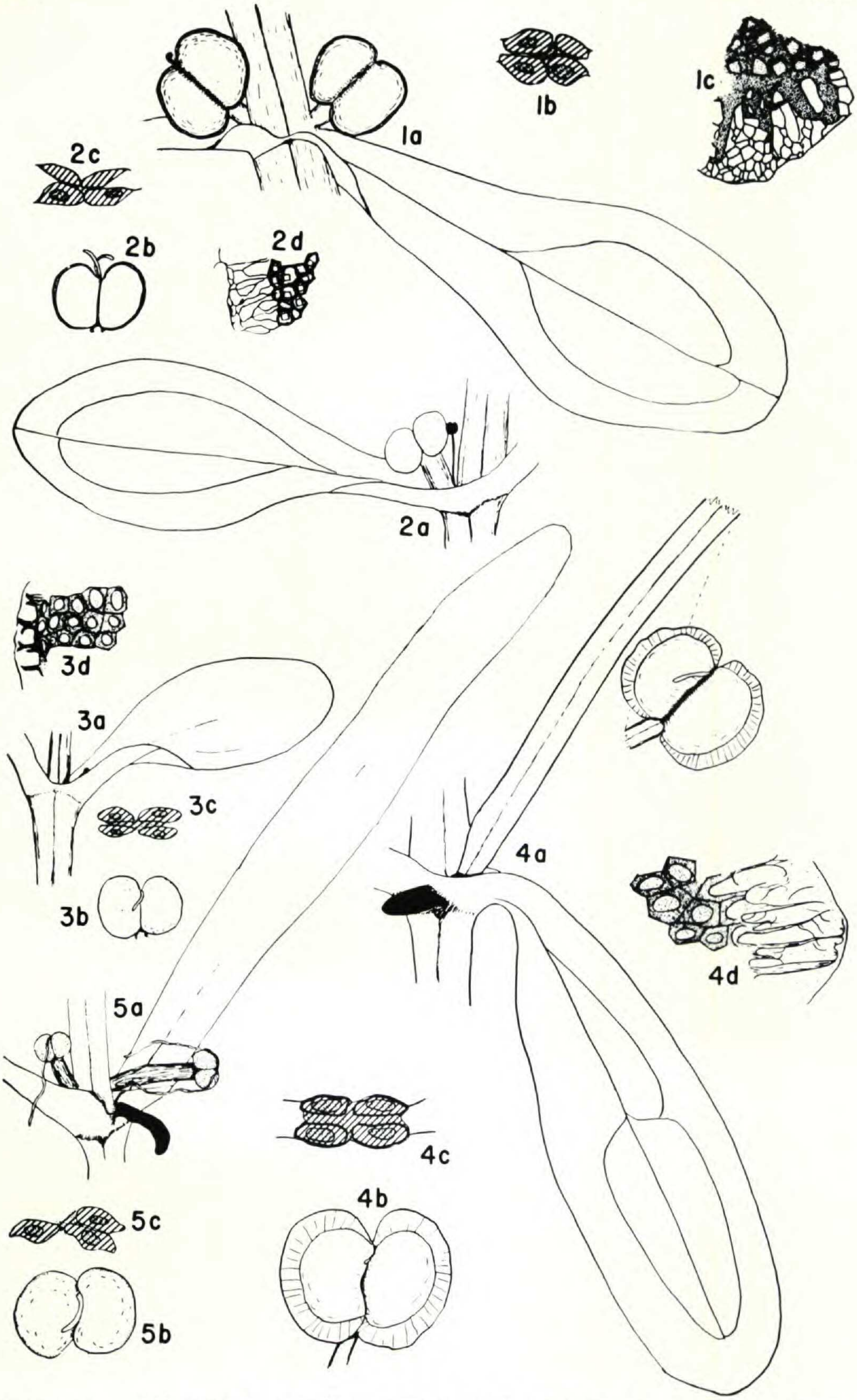
PLATE 1169

All figures are natural size, made by direct photographic prints from the pressed plants. All collections are in the Gray Herbarium.

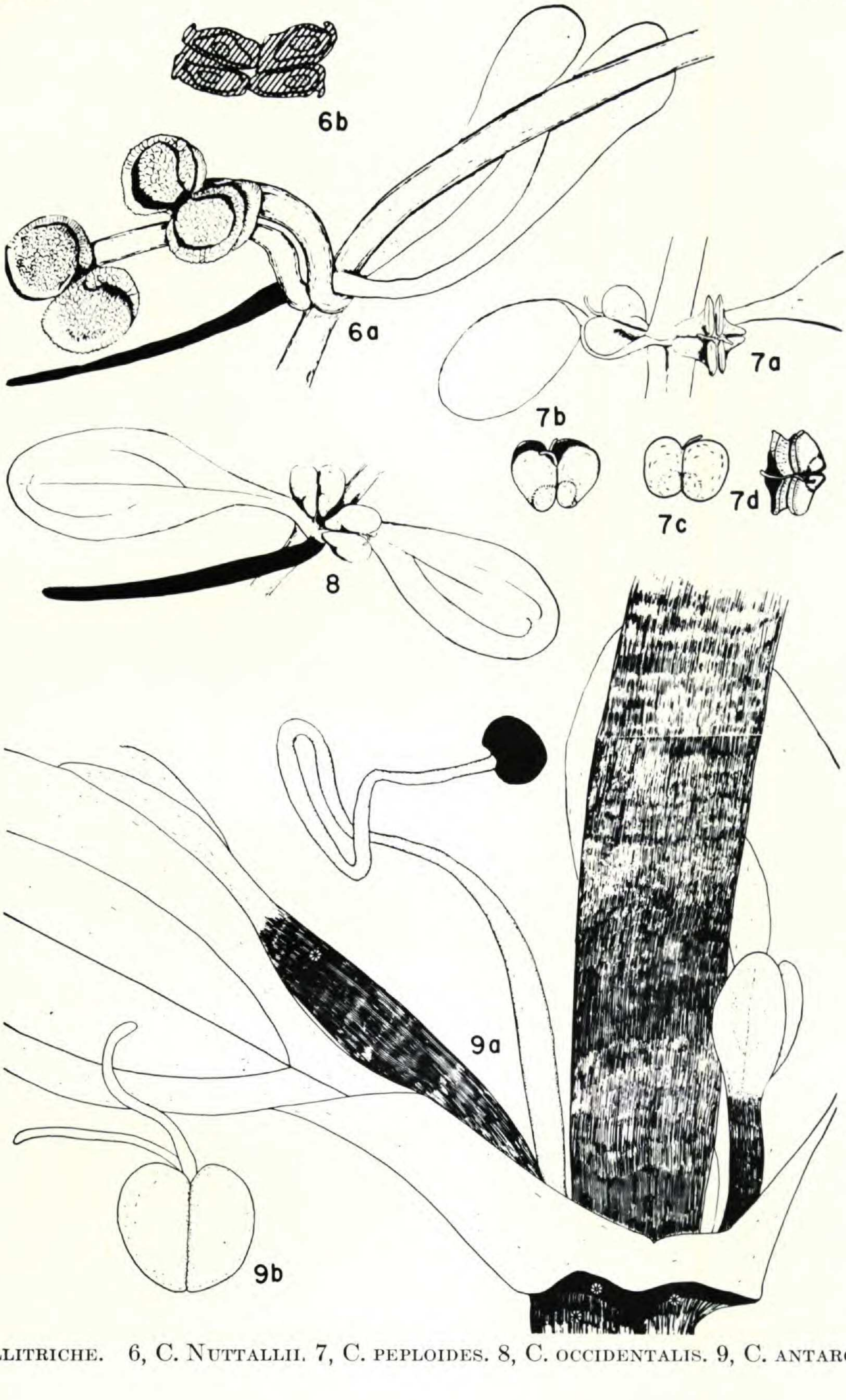
Fig. 1. *C. anceps*. Labrador, *Fernald, Wiegand & Long 28640*. Fig. 2. *C. anceps*. Labrador, *Fernald & Wiegand 3649*. Fig. 3. *C. anceps*. Newfoundland, *Fernald & Wiegand 3657*. Fig. 4. *C. anceps*. Newfoundland, *Robinson & Schrenk* in 1884. Fig. 5. *C. anceps*. Newfoundland, *Gilbert & Hotchkiss 28638*. Fig. 6. *C. anceps*. Quebec, *Victorin, Rolland & Jacques 33330*. Fig. 7. *C. anceps*. Quebec, *Fernald & Collins 234* (TYPE). Fig. 8. *C. anceps*. Georgia, *Svenson 7507*. Fig. 9. *C. anceps*. Quebec, *Fernald & Smith 25879*. Fig. 10. *C. turfosa*. Chile, *Johnston 5187*. Fig. 11. *C. antarctica*. Marion Island, *Mosley*. Fig. 12. *C. marginata*. California, *Mason 6810*. Fig. 13. *C. deflexa*. Brazil, *Rudio* (ISOTYPE). Fig. 14. *C. sepulta*. Oregon, *Hall 459* (TYPE).

CALLITRICHE HETEROPHYLLA

CALLITRICHE. 1–9, C. ANCEPS. 10, C. TURFOSA. 11, C. ANTARCTICA. 12, C. MARGINATA. 13, C. DEFLEXA. 14, C. SEPULTA.



CALLITRICHE. 1, C. TURFOSA. 2, C. DEFLEXA. 3, C. TERRESTRIS. 4, C. MARGINATA. 5, C. SEPULTA.



CALLITRICHE. 6, C. NUTTALLII. 7, C. PEPLOIDES. 8, C. OCCIDENTALIS. 9, C. ANTARCTICA.

pedicels was mentioned as the typical form. Three years later this concept was reaffirmed; the plant with stalked fruits was treated as α *Brauniana*, with *C. deflexa* A. Br. as a synonym, and the sessile-fruited plants of both continents separated as β *Austini*. For *Austini* three cotypes[1] were listed, from Missouri, New Jersey and Pennsylvania, so if the sessile-fruited plants of the United States are separated from those of Central and South America, the name *Austini* belongs with the former.

C. **deflexa** var. **deflexa**. *C. deflexa α Brauniana* Hegelm. Verhandl. Bot. Ver. Brandenburg 9: 15. 1867; Hegelm. in Martius, Fl. Bras. 13, pt. 2: col. 13. 1882. *C. deflexa β Glaziovii* Hegelm. in Martius, l. c.—Fruit (0.5–) 0.7–0.9 mm. wide, (0.3–) 0.5–0.7 mm. high, on stalks 0.5–4 mm. long.—East coast of South America from Rio de Janeiro to Buenos Aires. **Brazil**: Rio de Janeiro, 1859–60, *Dr. Rudio* (ex herb. A. Braun, and probably ISOTYPES, MO, CM, GH); Curityba, Paraná, 2. 10. 1914, *P. Dusén* (*G. Jönsson* written on some labels) *1044a* (MO, GH, CM, US, NY); Rio Grande do Sul, São Leopoldo, August, 1941, *Leite 2796* (GH) & *613* (NY); Santo Amaro, Cap., S. Paulo, Sept. 14, 1944, *Roth 939* (SP). **Uruguay**: Montevideo, Nov., 1936, *Herter 696a* (CM, MO). **Argentina**: LaPlata, Provincia de Buenos Aires, Oct. 19, 1943, *Cabrera 9805* (LP—mixed with var. *subsessilis*).

While the fruits are consistently larger than those of the next variety, an occasional individual has some of the fruits, ap-

PLATE 1170

(Numbers same as in keys and descriptions)

1. *C. turfosa*. 1a. Node, leaves and fruit, × 30. Argentina, *Eyerdam & Beetle 22385* (GH). 1b. Cross-section of fruit, × 30. Same collection. 1c. Portion of wing and face of fruit, × 187.5. Chile, *Johnston 5187* (GH).
2. *C. deflexa* var. *subsessilis*. 2a. Node, leaves, stamens and young fruit, × 30. Colombia, *Fassett 25071* (WIS). 2b. Face of fruit, × 30. Same collection. 2c. Cross-section of fruit, × 30. Same collection. 2d. Portion of wing and face of fruit, × 187.5. Same collection.
3. *C. terrestris*. 3a. Node, leaves and stamen, × 30. Illinois, *Chase 3903* (GH). 3b. Face of fruit, × 30. Same collection. 3c. Cross-section of fruit, × 30. Same collection. 3d. Portion of wing and face of fruit, × 187.5. Same collection.
4. *C. marginata*. 4a. Node, leaf, young root, and pedicelled fruit, × 30. California, *Tracy 1870* (UC). 4b. Face of fruit, × 30. California, *Tracy 1876* (UC). 4c. Cross-section of fruit, × 30. California, *Johnston 1948* (UC). 4d. Portion of wing and face of fruit, × 187.5. California, *Tracy 3137* (UC).
5. *C. sepulta*. 5a. Node, leaf, young fruits, and young root, × 30. Oregon, *Hall 459* (GH). 5b. Face of fruit, × 30. Same collection. 5c. Cross-section of fruit, × 30. Same collection.

PLATE 1171

(Numbers same as in keys and descriptions)

6. *C. Nuttallii*. 6a. Portion of stem, leaves, root, and pedicelled fruits, × 30. Alabama, *Mohr* on March 18, 1892 (NY). 6b. Cross-section of fruit, × 30. Same collection.
7. *C. peploides*. 7a. Node, leaves and fruits of var. *peploides*, × 30. Louisiana, *Langlois* in 1891 (NY). 7b. Face of fruit of var. *semialata*, × 30. Honduras, *Standley 56535* (CM). 7c. Face view of fruit of var. *media*, × 30. Guatemala, *Standley 83331* (CM). 7d. Top view of fruit, × 30. Same collection.
8. *C. occidentalis*. Portion of stem, leaves, root, fruits, × 30. Cuba, *Britton & Wilson 4515* (NY).
9. *C. antarctica*. 9a. Portion of stem, leaves, axillary buds, and stamen, × 30. Kerguelen's Land, *Kidder* in 1874 (US). 9b. Face of fruit, × 30. Same collection.

[1] Cf. Blake, Rhodora 45: 481–485. 1943.

parently mature, only about 0.5 mm. wide and 0.3 mm. high. Other parts of the same plant may bear fruits of normal size. *C. deflexa* var. *Glaziovii* was probably based on material with such small fruits; the collections cited by Hegelmaier have not been seen.

C. deflexa var. **subsessilis** n. var., fructibus 0.5–0.7 (–0.8) mm. latis, 0.3–0.5 (–0.6) mm. altis, cum alis 0.03–0.05 mm. latis; pedicillis 0.1–0.3 mm. longis. Fruits 0.5–0.7 (–0.8) mm. wide, 0.3–0.5 (–0.6) mm. high, with wings 0.03–0.05 mm. wide, and on pedicels 0.1–0.3 mm. long. *C. deflexa β Austini* Hegelm. Verhandl. Bot. Ver. Brandenburg 9: 15. 1867, and in Martius, Fl. Bras. 13, pt. 2: col. 13. 1882, as to South American plants but excluding the North American cotypes.—From Central Mexico southward to Argentina. **Mexico:** Nanchititla, Temascaltepec, 10–11–33, *Hinton 4988* (GH). **Guatemala:** Volcán Jumay, Jalapa, alt. 1300–2200 m., Dec. 1, 1939, *Steyermark 32440* (CM, NY); Guatemala, alt. 1500 m., Jan. 20, 1939, *Steyermaek 63106* (CM); Tajumulco, Dept. San Marcos, alt. 2300–2500 m., *Steyermark 36581* (CM). **Honduras:** Dept. Morazán, Río Yeguare, near El Zamorano, about 800 m., Feb. 27, 1947, *Standley & Molina 4671* (CM). **Colombia:** east of Bata, valley of Rio Chitagá, southwest of Pamplona, Dept. Norte de Santander, alt. 6500 ft., Oct. 13, 1944, *Fassett 25932* (TYPE in MO; CM, GH, US, NY, WIS); Vélez, Dept. Santander, April 17, 1944, *Fassett 25071* (MO, GH, WIS); Tequendama, Dept. Cundinamarca, Oct. 28, 1917, *Pennell 2648* (NY). **Brazil:** Caldas, prov. Minas Geraës, Sept. 22, 1867, *Regnell 1578* (NY, US, CM); Bello Jardim, Serra do Genipapo, Pernambuco, Nov. 14–15, 1924, *Chase 7710* (US); Ouro Preto, *Gomes 1751* (CM); Itatiba, S. Paulo, Nov. 26, 1930, *Leme 26697* (SP); Moóca, Cap., S. Paulo, Nov., 1912, *Brade 5778* (SP); Bahia, *Salzman* (MO). **Bolivia:** Región de Mapiri, San Carlos, Nov. 26, 1926, *Buchtien 1830* (NY). **Paraguay:** without locality, *Jörgensen 4509* (MO); Sud-Paraguay, *Kuntze* (NY). **Argentina:** Formosa, Aug., 1919, *Gonzalec 3240* (US, GH); Prov. Tucumán, Dept. Capital, 450 m., Aug. 1923, *Venturi 2052* (GH, US); Sierra de San Javier 14 kms. al oeste de Tucumán, July 14, 1949, *O'Donnell, Araque & Barkley 19Ar000* (US); Chaco, July, 1941, *Schulz 2996* (LP); Ribera de Rio de La Plata, Isla Santiago, Oct. 12, 1931, *Cabrera 1781* (LP); La Plata, Provincia de Buenos Aires, Oct. 19, 1943, *Cabrera 9805* (LP—mixed with var. *deflexa*).

3. **C. terrestris** Raf. emend. Torr. *C. terrestris* Raf. in Med. Repos. N. Y. 5: 358. 1808, *nomen ambiguum;* Torr. Comp. Fl. N. & Middle States 14. 1826; DC. Prod. 3: 71. 1828; House, N. Y. State Mus. Bull. no. 254: 473. 1924. *C. deflexa* A. Br. in Hegelm. Monogr. Callit. 58. 1864, as to some North American plants, not as to South American type. *C. deflexa β Austini* Hegelm. Verhandl. Bot. Ver. Brandenburg 9: 15. 1867, as to cotypes from Missouri and New Jersey, excluding cotype from Pennsylvania (*Moser*, 1832) and references to plants from South America; Morong, Bull. Torrey Club 18: 234. 1891; Robinson & Fernald in Gray's Manual, ed. 7: 550. 1908; Fassett, Man. Aquat. Pl. 241. 1940; Fernald in Gray's Manual, ed. 8: 973. 1950. *C. Austini* Engelm. apud Gray, Man. ed. 5: 428. 1867; Chapman, Fl. S. U. S., ed. 3: 420. 1897; Britton & Brown, Ill. Fl. North. States & Canada, vol. 2: 382. 1897; Small, Fl. Southeastern U. S. 723. 1903.—Fruit 0.6–0.9 mm. wide, 0.4–0.7 mm. high, on pedicels mostly 0.2 mm. long, rarely reaching 0.6 mm. long; mericarps usually equally rounded at each end (Fig. 3b) but rarely more broadly rounded above so that the fruit becomes slightly heart-shaped; faces of mericarps flat

(Fig. 3c); outer edges of mericarps appearing scarcely winged but under high magnification showing a very narrow wing with radii, but little anastomosing of radii (Fig. 3d); stigmas 0.2–0.4 mm. long, usually persistent and deflexed (Fig. 3b); anthers 0.1–0.2 mm. wide, on filaments 0.1–0.2 mm. long; leaves rather uniform, obovate-oblanceolate to spatulate, 2–3.5 mm. long, 0.6–1 mm. wide, very obscurely 3-nerved (Fig. 3a).—On damp soil, moist pathways, etc.; western Massachusetts and Connecticut to southeastern Virginia, westward in the mountains of Virginia, western Pennsylvania, northern Ohio, and in the Mississippi Valley from southern Indiana, northern Illinois and northern Missouri to Louisiana; apparently isolated in western Alabama. About half the collections examined are listed below. **Massachusetts:** Sunderland, Franklin Co., July 10, 1929, *Seymour 3385* (GH); Longfellow Park, Cambridge, July 1, 1945, *Hartman* (NEBC). **Connecticut:** Fairfield, July 22, 1898, *Eames 36* (US, GH); Southington, June 23, 1901, *Bissell* (GH); Southport, alt. 2–6 ft., July 17, 1891, *Eames 35* (GH). **New York:** Staten Island, May 26, 1889, *Britton* (NY). **New Jersey:** top of hills, Staten Island, N. Y., & Weehauken, N. J., June, 1842, *Austin* (NY, obviously two collections but no indication as to which is which); Paliasdes, Oct. 1864, *Austin* (MO—probably cotype *C. deflexa* var. *Austini*); Bergan Co., June 17, 1865, *Parker* (CM); Milltown, Middlesex Co., May 17, 1908, *Mackenzie 3059* (US). **Pennsylvania:** York Co., July 2–6, 1904, *Britton* (NY); Sellersville, 1883, *Fretz* (MO); Pittsburg, June 28, 1905, *Jennings & Kinzer 132* (MO). **Delaware:** Wilmington, June 15, 1881, *Commons* (GH, MO, US, NY); Townsend, *Canby* (CM); Leipsig, June 13, 1937, *Tatnall 3409* (GH). **Maryland:** Clinton, May 19, 1920, *Holm* (GH); Cecil Co., June 13, 1876, *Commons* (CM). **District of Columbia:** Brookland, May 10, 1896, *Holm* (US); Corcorans Woods, June 25, 1882, *Ward* (US). **Virginia:** Skipper's, Greenesville Co., May 21, 1939, *Fernald & Long 9968* (MO, GH, US, NY); Mt. Vernon, July 4, 1889, *Coville* (US); Stony Creek, Sussex Co., May 11, 1940, *Fernald & Long 11869* (GH); North Landing, Norfolk Co., May 6, 1935, *Fernald & Griscom 4447* (GH); Long Mt., Frederick Co., July 1, 1933, *Griscom & Hunnewell 18805* (GH). **Ohio:** Oberlin, Lorain Co., June 23, 1947, *Fassett 27645* (WIS). **West Virginia:** Petersburg, Grant Co., July 10, 1940, *Sharp & Fox* (WVA). **Kentucky:** Mammoth Cave, May 30, 1897, *Barnhart 2292* (NY); Hawesville, May 15, 1937, *Wadmond, Fassett, Curtis & Dunlop 21470* (WIS); Paducah, May 30–June 20, 1909, *Eggleston 4465* (NY). **Tennessee:** Nashville, May, *Gattinger 2463* (CM, MO, US, GH, NY); Chester Co., June, 1892, *Bain* (US); Memphis, May 20, 1851, *Fendler* (MO). **Alabama:** Auburn, Lee Co., April 16, 1898, *Earle & Baker* (MO, mixed with *C. Nuttallii*). **Indiana:** Henryville, Clark Co., June 18, 1935, *Hermann 6754* (GH); Leavenworth, Crawford Co., June 16, 1935, *Hermann 6685* (NY); Princeton, June 14, 1935, *Hermann 6607* (US). **Illinois:** Peoria, May 28, 1922, *Chase 3903* (GH); Menard Co., June 1878, *Hall* (CM); Mt. Carmel, May 9, 1888, *W. T.* [*release*] (MO); Richland Co., April 23, 1926, *Ridgeway 2482* (MO); Giant City State Park, Jackson Co., May 14, 1937, *Fassett 21471* (WIS); Cobden, Union Co., May 23, 1902, *Earle 699* (NY). **Missouri:** banks of the Mississippi south of the Meramec, May 28, 1864, [*Engelmann*] (MO, US, CM—probably COTYPE of *C. deflexa* var. *Austini*); Molino, Audrain Co., May 14, 1939, *Steyermark 22468* (CM); Eagle Rock, Barry Co., June 12, 1897, *Bush 64* (MO, US); Coloma, Carroll Co., June 25, 1938, *Steyermark 6195* (CM); Dunklin Co., May 17, 1892, *Bush* (MO); Gray Summit, Franklin Co., June 20, 1928, *Kellogg 1835* (MO); Grain Valley, June 19, 1898, *Bush 90* (MO, NY); Sarcoxie, Jasper Co., May 19, 1912, *Palmer 3681* (MO); Jasper, Jasper Co., July 17, 1910, *Palmer 3015* (MO); Foley,